ARCADIS GERAGHTY & MILLER

ARCADIS G&M, Inc.
2900 West Fork Drive
Suite 540
Baton Rouge
Louisiana 70827
Tel 225 292 1004
Fax 225 292 5210
www.arcadis-us.com

ENVIRONMENT

Mr. Michael Vince, Administrator
Louisiana Department of Environmental Quality
Office of Environmental Services, Permits Division
P.O. Box 82135
Baton Rouge, Louisiana 70884-2135

Subject:
Request for Site-Specific Treatability Variance for Acrylic Acid in Soils
Eunice Train Derailment, May 27, 2000
Agency Interest No. ~~82576~~ 85276

Date:
20 May 2002

Contact:
George H. Cramer, II

Extension:
228

Email:
gcramer@arcadis-us.com

Our ref:
LA001993.0001.00002

Dear Mr. Vince:

ARCADIS is submitting this petition for a site-specific variance from the treatability standard for acrylic acid for the soils at the Eunice, Louisiana site on behalf of the Union Pacific Railroad Company (UPRR). Specifically the petition is submitted in accordance with LAC 33:V.2231.G, the applicable sections of which are shown below.

G. Based on a petition filed by a generator or treater of hazardous waste, the administrative authority may approve a site-specific variance from an applicable treatment standard if:

1. (Not Applicable); or

2. it is inappropriate to require the waste to be treated to the level specified in the treatment standard or by the method specified as the treatment standard, even though such treatment is technically possible. To show that this is the case, the petitioner must either demonstrate that:

a. treatment to the specified level or by the specified method is technically inappropriate (e.g., resulting in combustion of large amounts of mildly contaminated environmental media where the treatment standard is not based on combustion of such media); or

b. (Not Applicable);

3. for contaminated soil only, treatment to the level or by the method specified in the soil treatment standard would result in concentrations of hazardous constituents that are below (i.e., lower than) the concentrations necessary to minimize short and long term threats to human health and the environment. Treatment variances approved under this Subsection must:

a. at a minimum, impose alternative land disposal restriction treatment standards that, using a reasonable maximum exposure scenario:

i. (Not Applicable);

ii. for constituents with noncarcinogenic effects, achieve constituent concentrations that an individual could be exposed to on a daily basis without appreciable risk of deleterious effect during a lifetime;

b. not consider post-land-disposal controls;

The information specifically requested in LAC 33.I.907.C. and the above specified sections of LAC 33:V.2231.G is provided below.

I. Petitioner's Name and Address (§ 907.C.1.)

Union Pacific Railroad
24125 Aldine Westfield Road
Spring, Texas 77373-9015
Contact: Geoffrey Reeder

II. Petitioner's Interest in the Proposed Action (§ 907.C.2.)

UPRR is the generator of a large volume of impacted soil media from a train derailment site northwest of the town of Eunice, Louisiana. Approximately 1,500 tons of this soil has been mildly contaminated by acrylic acid (U008). UPRR has undertaken the clean up environmental media at the site impacted by the chemicals carried in the derailed railcars.

III. Basis for the Requested Variance (§ 907.C.3.)

Acrylic acid in its pure form is a listed waste due to ignitability. The treatment standard for this compound is incineration. Based upon LAC 33:V.2231.G.2.a, UPRR believes that treatment of this impacted media by incineration is technically inappropriate, resulting in the incineration of a large volume of this soil (1,500 tons) solely because it is impacted by low levels of acrylic acid (the highest residual concentration detected to date is 240 milligrams per kilogram [mg/Kg]). This equates to less than one tenth of one percent by volume of the soil even if all the soil were impacted by this concentration. In addition, the acrylic acid at the site does not exhibit the same nature as the acrylic acid utilized in the determination of the hazardous waste characteristic of ignitability. The waste material polymerized during the release, becoming a solid material, and is no longer ignitable. Although occasional exposed pieces of the polymerized material have been found at or near the surface of the ground, in the 2 years since the derailment, no acrylic acid has ignited at the site. Additionally, soil with this concentration of acrylic acid was tested for ignitability as part of the waste characterization during the initial removal operation. The soil was determined not to be ignitable.

IV. ...Proposed Regulations or Amendments... (§ 907.C.4.)

No regulations or amendments to regulations are anticipated due to this action.

V. Other Information that Justifies the Proposed Action (§ 907.C.5.)

Treatment of the contaminated soil by incineration would result in concentrations of hazardous constituents (acrylic acid) that are below the concentrations necessary to minimize short and long term threats to human health and the environment. Acrylic acid exhibits non-carcinogenic effects. In accordance with LAC 33:V.2231.G.3.a.ii, ARCADIS has calculated concentration limits (attached), under Management Option – 1 (MO-1) that an individual could be exposed to on a daily basis without appreciable risk of deleterious effect during a lifetime. These MO-1 limits are based upon Screening Standard concentrations already calculated by ARCADIS, submitted in the Site Investigation Report for Eunice City Lake, and accepted by the LDEQ (also attached). The MO-1 standard (100 mg/Kg) is based on an industrial exposure scenario.

The acrylic acid that is in the soil does not readily leach from the soil. Synthetic Precipitate Leaching Procedure (SPLP) samples collected from the impacted areas of the right-of-way documented that the acrylic acid is not mobile. As shown in the Railbed Report (February 2002) the SPLP sample collected from the area of highest acrylic acid concentrations had an SPLP concentration of only 0.066 milligrams per liter (mg/L) which is three orders of magnitude below a concentration that is protective of groundwater. Therefore, landfilling of this soil will not create an environmental hazard due to the leaching of the acrylic acid.

Based upon the information provided above, UPRR proposes to dispose of soil containing concentrations of 100 mg/Kg or less of acrylic acid by direct landfilling at a Subtitle C (Hazardous Waste) landfill. Landfilling of acrylic acid contaminated soil, below the MO-1 industrial level, will remain protective of human health and the environment. UPRR proposes to dispose of the soil impacted by acrylic acid above the MO-1 concentration of 100 mg/Kg by incineration.

UPRR will comply with all applicable requirements for restricted wastes found under LAC 33:V.2245 and 2247.

ARCADIS

Mr. Michael Vince
20 May 2002

Certification

Based upon a thorough review of the information pertinent to this petition, the engineer providing oversight of this project makes the following certification:

> *I certify under penalty of law that I have personally examined and am familiar with the information submitted in this petition and all attached documents and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fines and imprisonment.*

Sincerely,

ARCADIS G&M, Inc.

David R. Escude'
Principal Engineer
La. Registration No. 23071

STATE OF LOUISIANA
DAVID R. ESCUDE
REG. No. 23071
REGISTERED
PROFESSIONAL ENGINEER
IN
CIVIL ENGINEERING

George H. Cremer, II, P.G.
Associate Vice President/Hydrogeologist

Rudy J. Guichard
Vice President/Area Manager

DRE:GHC:RJG:ndw

Attachments

Copies
Geoffrey Reeder/Union Pacific
David Young/Union Pacific
Steven Levine/Phelps Dunbar
Dr. James H Brent/LDEQ
Mr. Douglas Bradford/LDEQ

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Table 1. RECAP Limiting Industrial Soil MO-1 RECAP Standards (RS) for the Railbed Proper, Union Pacific Railroad Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

	Limiting MO-1 Industrial $Soil_{RS}$ (mg/kg)
VOCs	
1,2-Dichloropropane	0.042
Chloromethane	0.1
n-Hexane	110
SOVCs	
Acrylic Acid	100
Benz(a)anthracene	0.33*
Dicyclopentadiene	5.4
Disodium Iminodiacetate	150
Naphthalene	32
Phenol	990
2,4-Toluenediamine	1.67*
Toluene Diisocyanate	0.66*
Inorganics	
Aluminum	74,000

The limiting industrial $Soil_{RS}$ was based on the lowest of the $Soil_i$, the $Soil_{GW3NDW}$, and the $Soil_{sat}$.

$Soil_i$	Soil MO-1 RECAP standard based on the protection of human health for industrial land use; from RECAP Table 2 when available (applicable to railbed proper); modifications to account for additive effects are shown in parentheses.
$Soil_{GW3NDW}$	Soil MO-1 RECAP standard for soil concentration protective of groundwater classification 3; from RECAP Table 2 when available; a dilution factor (DF) was conservatively not applied due to the proximity of the tributary to the Railbed.
$Soil_{sat}$	Soil saturation concentration (from RECAP Table 2 when available).
mg/kg	milligrams per kilogram.
*	If the calculated RS was less than the sample quantitation limit (SQL), the SQL was used as the RS.

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RECAP Screening Standards for Union Pacific Railroad Train Derailment

Eunice Train Derailment 52700 - May 27, 2000
Agency Interest No. 85276

PREPARED FOR

Union Pacific Railroad Company

ARCADIS

Carol E. Mueller, M.S.P.H.
Scientist/Toxicologist

Lance W. Fontenot, Ph.D.
Senior Scientist/Toxicologist

Rudy J. Guichard
Vice President/Area Manager

RECAP Screening Standards for Union Pacific Railroad Train Derailment

Eunice Train Derailment 52700 - May 27, 2000 Agency Interest No. 85276

Prepared for:
Union Pacific Railroad Company

Prepared by:
ARCADIS Geraghty & Miller, Inc.
2900 West Fork Drive
Suite 540
Baton Rouge
Louisiana 70827
Tel 225 292 1004
Fax 225 292 5210

Our Ref.:
LA001993.0001.00002

Date
20 April 2001

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Tables

1.0 Introduction

The objective of this report is to present risk-based screening standards using the equations provided in the Louisiana Department of Environmental Quality Risk Evaluation/Corrective Action Program (RECAP; LDEQ 2000; LAC 33:I.Chapter 13). RECAP Screening Standards (SS) will be used to: (1) evaluate preliminary sample quantitation limits (SQL); (2) establish an Area of Investigation (AOI) and constituents of concern (COCs) in accordance with RECAP Site Investigation requirements; and (3) provide an approach for deriving site specific RECAP Standards (RS) for the COCs after the Site Investigation activities are completed. The approach for defining AOI for the Eunice Train Derailment site is contained in the "Revised Work Plan, Environmental Site Investigation (ARCADIS Geraghty & Miller July 12, 2000) which was approved by LDEQ on July 25, 2000.

This report is concerned with the "short-list" of derailment-related COCs. The "short-list" of COCs includes the chemicals contained in the breached rail cars or surrogate chemicals identified as indicators of the presence of a chemical contained in the breached rail cars. A toxicity assessment for the COCs was conducted in order to identify appropriate toxicity values for use in calculating risk-based concentrations in soil, surface water, and edible fish tissue. To support the toxicity assessment, toxicological and environmental fate data were compiled from a technical literature review for the COCs.

Risk-based SS for non-industrial soil ($Soil_{SSni}$, $Soil_{SSGW}$, and $Soil_{sat}$), groundwater (GW_{SS}), surface water (SW_{NDW}), and edible fish tissue (Risk-Based Concentration [RBC]) were calculated. The soil SS were calculated from equations taken directly from Appendix H and I of RECAP (LDEQ 2000). The soil SS presented herein are based on the assumption that the area of impacted soil under investigation is approximately 0.5 acre or less. If after completion of the Site Investigation the area of impacted soil is determined to be greater than 0.5 acre, the soil SS will require modification to the actual area of impacted soil.

The groundwater SS were calculated from equations taken directly from Appendix H of RECAP (LDEQ 2000). The surface water standard utilized the RECAP Management Option 1 (MO-1) equations for Groundwater Classification 3 Non-Drinking Water ($GW3_{NDW}$) because the point of exposure for a GW3NDW groundwater source is assumed to be at the point of discharge to a surface water body. Therefore, the $GW3_{NDW}$ is assumed to be representative of a surface water RECAP

Standard and is also consistent with Human Health Numerical Criteria Derivations for Toxic Substances (LDEQ 1994). The RBC for edible fish tissue is based on the equation presented in the U.S. Environmental Protection Agency (USEPA) Region III Report on the development of risk-based concentrations (USEPA Region III Risk-Based Concentration Table: Technical Background Information, 1999).

The following RECAP Standards were calculated:

$Soil_{SSnr}$	The RECAP soil screening standard based on the protection of human health for non-industrial land use.
$Soil_{SSGW}$	The RECAP soil screening standard based on the protection of groundwater meeting the definition of Groundwater Classification I (compliance with GW_{SS}).
$Soil_{sat}$	The MO-1 RECAP Standard based on the concentration that represents a chemical-physical limit where saturation of the soil occurs. Constituent concentrations in soil at or above the $Soil_{sat}$ indicate a potential for non-aqueous phase liquid (NAPL) to be present in the soil.
GW_{SS}	The RECAP groundwater screening standard based on the protection of groundwater meeting the definition of Groundwater Classification 1.
SW_{NDW}	The modified surface water RECAP Standard utilizing the GW3NDW equations that assumes a point of discharge into a surface water body.
RBC	Calculated risk-based concentrations for edible fish.

2.0 Methods

While RECAP provides screening standards for chloromethane, phenol, and 1,2-dichloropropane, no standards are available for other "short-list" COCs. Therefore, RECAP SS for such constituents were calculated using the equations provided in RECAP Appendix H and I (LDEQ 2000). The first step in preparation for doing such calculations was to compile physical and chemical information (Table 1), as well as toxicological information (Tables 2 and 3) on these constituents. Such data were obtained primarily from RECAP, USEPA Region III and Region IX documents.

Occasionally, the information needed for a specific chemical was not available. When chemical-specific dermal absorption factors (ABS) were not available, organic constituents were assumed to have an ABS of 0.1 and inorganic constituents an ABS of

0.01, as taken from Appendix H, Table H-1 of RECAP (LDEQ 2000). Henry's Law constants were calculated with the following equation when not available: H = (vapor pressure * molecular weight)/solubility. The equation is based on the Henry's Law Constant formula in USEPA's "Soil Screening Guidance: Technical Background Document" (USEPA 1999). The air diffusivities (D_i) and water diffusivities (D_w) were calculated following the formulas provided in Appendix H of RECAP. D_i and D_w were estimated using the algorithms below:

chemical a = chemical in question

chemical b = phenol (with published diffusivity value)

$$D_i = \frac{D_{ib}}{D_{ia}} = \sqrt{\frac{MW_a}{MW_b}}$$

$$D_w = \frac{D_{wb}}{D_{wa}} = \sqrt{\frac{MW_a}{MW_b}}$$

K_{oc} represents the organic carbon/ water partition coefficient, and K_{ow} represents the octanol/water partition coefficient. If a K_{oc} or K_{ow} was not available in the literature, a representative value was estimated using the algorithm from Appendix I of RECAP (LDEQ 2000).

$\text{Log } K_{oc} = 0.0784 + (0.7919 \times \log K_{ow})$

When necessary, a bioconcentration factor (BCF) was estimated using the K_{ow} and the algorithm from Appendix I of RECAP (LDEQ 2000).

$\text{Log BCF} = 0.76 \log K_{ow} - 0.23$

Toxicity values were also located for the constituents involved. As reported in RECAP (LDEQ 2000), toxicity values are obtained from the following hierarchy of sources: (1) USEPA's Integrated Risk Information System (IRIS), an on-line database of toxicity information updated monthly (USEPA 2000); (2) USEPA's Health Effects Assessment Summary Tables toxicological profiles (HEAST; (USEPA 1997); (3) USEPA Region III Risk-Based Concentration Tables (USEPA 1998a); or (4) USEPA Region IX Preliminary Remediation Goals Tables (USEPA 1998b). Additional

sources are presented in the References section (Section 4). Occasionally, the available toxicological information needed to be converted to a form required by RECAP Standard equations. The inhalation reference dose (RfD_i) can be calculated by converting a reference concentration (RfC) for noncarcinogenic effects using the following equation found in USEPA Region IX's 1999 Preliminary Remediation Goals Report (Oct. 1, 1999).

$$RfD_i \frac{mg}{(kg-day)} = RfC(mg/m^3) \times \frac{20m^3}{day} \times \frac{1}{70kg}$$

A similar equation was used to convert the unit risk factors (URF) for carcinogenic effects to the inhalation cancer slope factor (CSF_i) using the following equation found in USEPA Region IX's 1999 Preliminary Remediation Goals Report (Oct. 1, 1999).

$$CSF_i \frac{(kg-day)}{(mg)} = URF(m^3/ug) \times \frac{day}{20m^3} \times 70kg \times \frac{10^3 ug}{mg}$$

3.0 Results

Available RECAP Standards for surface soil were utilized for the constituents that have such standards. As previously mentioned, some of the constituents do not have RECAP Standards. The soil SS for non-industrial land use ($Soil_{SSni}$), the soil SS for protection of groundwater ($Soil_{SSGW}$), and the soil SS for soil saturation concentration ($Soil_{sat}$) provide conservative risk-based SS for defining the AOI. The definition of AOI is critical for future applications of RECAP for corrective action options at the site. Table 4 shows the available or calculated soil standards for the COCs. Also, sample calculations for three constituents, acrylic acid, dicyclopentadiene, and 2,4-toluenediamine, are provided in Table 5.

In addition, RECAP Standards are not available for sediments. Therefore, it is proposed that using the soil SS for sediments will be protective of human health. Although surface soils found in the tributary area and adjacent wetlands at the site are saturated during certain portions of the year, the soil screening standard (SS) for non-industrial land use ($Soil_{SSni}$) and the soil SS for protection of groundwater ($Soil_{SSGW}$). provide conservative risk-based SS for defining the Area of Investigation (AOI).

Available RECAP Standards for groundwater were utilized for the constituents that have such standards. As previously mentioned, some of the constituents do not have RECAP Standards. The groundwater screening standard (GW_{SS}) is based on the protection of groundwater meeting the definition of Groundwater Classification 1. In accordance with RECAP, the Maximum Contaminant Level (MCL; Safe Drinking Water Act) was identified as the GW_{SS} when available. If an MCL was not available, a risk-based GW_{SS} was developed using the equations provided in RECAP Appendix H (LDEQ 2000). The exposure pathways that were considered in the development of the risk-based GW_{SS} include the ingestion of groundwater and the inhalation of volatile emissions associated with indoor groundwater use. Table 6 shows the calculated GW_{SS} and sample calculations for three constituents (acrylic acid, dicyclopentadiene, and 2,4-toluenediamine) provided in Table 7.

RECAP Standards for surface water are not available. The equations for GW3NDW were used to develop a risk-based surface water standard. Because the point of exposure for GW3NDW groundwater is assumed to be at the point of discharge to a surface water body, it is assumed to be representative of a surface water RS. The GW3NDW equations are also consistent with LDEQ Human Health Numerical Criteria Derivations for Toxic Substances (LDEQ Office of Water Resources 1994). In Table 8 the calculated GW3NDW RS for surface water is referred to as Surface Water Non-Drinking Water (SWNDW). Table 9 provides sample calculations of the SWNDW standard.

RECAP Standards are also not available for fish. Therefore, to evaluate the constituent concentrations in fish collected from surface waters near the derailment area, a risk-based concentration was calculated. The RBC for edible fish tissue is based on the equation in USEPA's Region III Report on the development of risk-based concentrations (USEPA Region III Risk-Based Concentration Table: Technical Background Information, 1999). The USEPA Region III exposure assumption for fish ingestion (0.054 kg/d) was adjusted to match the RECAP input for fish ingestion (0.02 kg/d). Table 10 shows the calculated RBCs for edible fish tissue, as well as any USEPA Region III RBCs available for comparison. Sample calculations for RBCs are provided in Table 11.

If any of the calculated RECAP Standards are less than the analytical quantitation limit, the analytical reporting limit is used as the limiting Screening Standard for that specific medium (e.g., soil, groundwater, surface water, fish tissue) (LDEQ 2000). The Reporting Limits utilized are in accordance with established standard EPA approved methodologies. Reporting Limits are generally determined through application of a

multiplication factor to the statistically derived Method Detection Limit (MDL) for an individual compound. MDLs are established in accordance with protocols set forth in 40 CFR Part 136. For reporting purposes associated with this project, if a detection occurs between the MDL and the reporting limit, values will be reported with a "J" qualifier indicating that the concentration is estimated. Therefore, if a non-detect is reported, the presumption is that the compound was not reportable above the MDL. With the exception of 2,4-toluenediamine and toluene diisocyanate, all fish tissue RBCs were greater than the laboratory analytical detection limits.

4.0 References

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Table 1 Physical and Chemical Properties for Constituents of Concern, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana

Constituent	Molecular Weight (g/mol)		Water Solubility (mg/L)		Henry's Law Constant (atm-m^3/mol)		Henry's Law Constant (unitless)	Diffusivity in Air (cm^2/sec)		Diffusivity in water (cm^2/sec)		Koc (mL/g)		BCF (L/kg)	
Acrylic Acid	72 06	b	1 00E+06	c	3 20E-07	c	1 31E-05	9 37E-02	cal	1 04E-05	cal	43	c	1	c
Aluminum	26 98	c	0	d	NA		NA	1.53E-01	cal	1 70E-05	cal	1500	f	1 05	cal
Caprolactam	113 16	c	5 25E+06	c	5.40E-11	c	2 21E-09	7 48E-02	cal	8 30E-06	cal	57	c	3 2	c
Chloromethane	50 49	a	5.30E+03	a	8 80E-03	a	3.61E-01	1 26E-01	a	6 50E-06	a	25 1	a	2 89	a
Cyanide *	26	c	1 00E+06	c	1.33E-04	c	5.45E-03	1 56E-01	cal	1 73E-05	cal	18	j	1	a
1,2-Dichloropropane	112 99	a	2 80E+03	a	2 80E-03	a	1 15E-01	7.82E-02	a	8.73E-06	a	47	a	19 5	a
Dicyclopentadiene	132 21	c	0	g	1 07E-02	c	4 39E-01	6 92E-02	cal	7 68E-06	cal	894	c	93 2	c
Disodium Iminodiacetate	177 07	g	NA		NA		NA	5 98E-02	cal	6 63E-06	cal	NA		NA	
Ethylene Glycol	62 07	h	1 00E+05	g	6 00E-08	c	2 46E-06	1 01E-01	cal	1 12E-05	cal	4 0	c	10	c
n-Hexane	86 18	d	9 5	c	1 81E+00	c	7 42E+01	8.57E-02	cal	7 18E-06	cal	1250 - 4100	c	0 35 - 0 46	c
Neopentyl Glycol	104 15	g	1 86E+06	l	NA		NA	7 79E-02	cal	8 65E-06	cal	NA		NA	
Pentane	72 15	c	3 85E+01	c	1 26E+00	c	5 17E+01	9 37E-02	cal	1 04E-05	cal	1600	c	0 28 - 0 37	c
Phenol	94 11	a	8 28E+04	a	3 97E-07	a	1 63E-05	8 20E-02	a	9 10E-06	a	28 8	a	8 13	a
2,4-Toluenediamine	122 17	c	7 74E+03	c	1 20E-09	c	4 92E-08	7 20E-02	cal	7 99E-06	cal	1 56	c	1 06	c
Toluene Diisocyanate	174 16	c	3 76E+01	e	1 11E-05	e	4.55E-04	6 03E-02	cal	6 69E-06	cal	1096 75	e/cal	410	e/cal

Note The unitless Henry's Law Constant is calculated (1/RT) x the value in atm-m^3/mol

* Values reported for cyanide water solubility, Henry's Law constant, and Koc are for hydrogen cyanide, cyanide information was not available

References IRIS, 2000; NLM, 2000, LDEQ RECAP 2000, USEPA Region IX, 1999, or were calculated in accordance with LDEQ or EPA

a	RECAP, LDEQ 2000	atm-m^3/mol	Atmospheres-cubic meters per mole
b	IRIS, 2000	cm^2/sec	Square centimeters per second
c	National Library of Medicine, HSDB 2000.	g/mol	Grams per mole
d	ATSDR for individual constituent	Koc	Organic carbon partition coefficient
e	SRC Physical Properties Database	mg/L	Milligrams per liter
f	Baes, et al , 1984	mL/g	Milliliters per gram
g	Chemfinder, 2000	NA	Not available
h	EPA OAQPS, UATW	RT	Ideal gas constant x absolute temperature (0 02445 atm-m^3/mol)
i	WHO/IPCS/ILO		
j	USEPA Region 9 PRG Tables		
cal	Calculated using formula from RECAP, LDEQ 2000		

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Table 2 Oral Reference Doses, Inhalation Reference Concentrations, Target Sites, and Confidence Levels for Constituents of Concern, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

Constituent	Oral RfD (mg/kg/day)		Inhalation RfD (mg/kg/day)		RfC (mg/m^3)		Target Sites		Confidence Level/ Uncertainty Factor	
							Oral	Inhalation	Oral	Inhalation
Acrylic Acid	0 5	b	0.00029	d	0.001	d	cellular necrosis	nose	high/100	medium/300
Aluminum	1.0	d	0 0014	d	0.005	e	bone, CNS	lung	NA	NA
Caprolactam	0 5	b	0.5	b	NA		reproductive	respiratory	high/100	NA
Chloromethane	0.086	a	0.086	a	NA		GI	CNS, liver, kidney, skin	NA	NA
Cyanide, Total*	0.02	a	0 02	a	NA		liver	NA	medium/100	NA
1,2-Dichloropropane	0 00114	a	0.00114	a	0.004	b	blood, liver, kidney	liver, kidney	NA	medium/300
Dicyclopentadiene	0.03	h	0.000057	h	0 00020	h	CNS, respiratory	CNS,cardiovascular	NA	NA
Disodium Iminodiacetate	NA		NA		NA		NA	NA	NA	NA
Ethylene Glycol	2.0	b	2.0	d	0.4	f	CNS, cardiovascular	NA	high/100	NA
n-Hexane	0.06	h	0 0571	d	0.2	b	GI	CNS, polyneuropathy	NA	medium/300
Neopentyl Glycol	NA		NA		NA		NA	NA	NA	NA
Pentane	NA		NA		NA		lung	CNS, cardiovascular	NA	NA
Phenol	0 6	a	0 6	a	NA		liver, kidney	skin, eyes, nasal	low/100	NA
2,4-Toluenediamine	NA		NA		NA		NA	NA	NA	NA
Toluene Diisocyanate	0 23	c	0 00002	g	0 00007	b	liver, kidney, GI	respiratory, skin	NA	medium/30

References: IRIS, 2000; NLM, 2000, LDEQ RECAP 2000, USEPA Region IX, 1999

* As a conservative measure, data for most toxic form of cyanide (free cyanide) was used.

CNS Central nervous system.

GI Gastrointestinal

mg/kg/day Milligrams per kilogram per day.

mg/m^3 Milligrams per cubic meter

NA Not available

RfC Inhalation reference concentration.

RfDo Oral reference dose.

VOCs Volatile organic compounds.

a RECAP (LDEQ 2000).

b USEPA. 2000. Integrated Risk Information Systems (IRIS)

c National Library of Medicine. 2000. Hazardous Substances Database.

d USEPA Region IX Preliminary Remediation Goals Tables, 1999.

e USEPA, Office of Pollution Prevention and Toxics. TRI Risk-Screening Environmental Indicators September 1998.

f Office of Environmental Health Hazard Assessment. 1999. California Environmental Protection Agency. Air Toxics Hot Spots Program Risk Assessment Guidelines, Part III, Draft Technical Support Document for the Determination of Noncancer Chronic Reference Exposure Levels. May and September, 1999.

g Calculated from RfC following EPA Region IX Equation.

h HEAST

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Table 3. Oral Cancer Slope Factors, Inhalation Cancer Slope Factors, Tumor Sites, and USEPA Cancer Classifications for Constituents of Concern, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

Constituent	Oral CSF (kg-day/mg)		Inhalation CSF (kg-day/mg)		Tumor site		USEPA Classification
					Oral	Inhalation	
Acrylic Acid	NC		NC		NA	NA	
Aluminum	NC		NC		NA	NA	
Caprolactam	NC		NC		NA	NA	
Chloromethane	0.013	a	0.0035	a	NA	NA	C
Cyanide	NC		NC		NA	NA	
1,2-Dichloropropane	0.068	a	0.068	a	liver	NA	B2
Dicyclopentadiene	NC		NC		NA	NA	
Disodium Iminodiacetate	NA		NA		NA	NA	
Ethylene Glycol	NC		NC		NA	NA	
n-Hexane	NC		NC		NA	NA	
Neopentyl Glycol	NA		NA		NA	NA	
Pentane	NA		NA		NA	NA	
Phenol	NC		NC		NA	NA	
2,4-Toluenediamine	3.20	b	3.20	b	liver	NA	B2
Toluene Diisocyanate	0.039	c	0.0385	c	liver, pancreas	NA	B2

References: LDEQ RECAP, 2000 (a); USEPA Region IX, 1999 (b); California EPA (c); National Library of Medicine (HSDB), 2000.

* Toluene Diisocyanate has not been formally listed as a carcinogen by the USEPA, but as a conservative measure the California EPA carcinogenic evaluation was used.

B2 Probable human carcinogen with sufficient evidence in animals and inadequate or no evidence in humans.

C Possible human carcinogen.

CSF Cancer slope factor.

kg-day/mg Kilograms-day per milligram.

NA Not available.

NC Not a carcinogen.

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Table 4 Calculation of RECAP Screening Standards for Soil, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana

Constituent	Soil_SSni (mg/kg)	Soil_SSGW (mg/kg)	Soil_sat (mg/kg)
Acrylic Acid	[illegible]	139	381531
Aluminum	7495 38	[illegible]	NAP
Caprolactam	1932 57	[illegible]	2444029.41
Chloromethane(Methyl Chloride)	5 80	[illegible]	1600
Cyanide (total)	[illegible]	400(1)	232005.72
1,2-Dichloropropane	0.69	[illegible]	1,200
Dicyclopentadiene	[illegible]	1.11	NAP
Disodium Iminodiacetate	NA	NA	NA
Ethylene Glycol	5893.77	[illegible]	14752.96
n-Hexane	[illegible]	158.67	215 23
Neopentyl glycol*	5893.77	[illegible]	274405 11
n-Pentane	[illegible]	99.70	548.08
Phenol	2100	[illegible]	24536 19
2,4-Toluenediamine	0 08	[illegible]	1028.56
Toluene Diisocyanate	[illegible]	2 68	251 87

mg/kg	milligrams per kilogram.
NA	Not available
NAP	Not applicable.
RECAP	Risk Evaluation/Corrective Action Program.
Soil_sat	Soil screening standard based on the concentration at which the pore spaces in the soil medium are saturated constituent of concern; from RECAP Table 2 when available.
Soil_SSGW	Soil screening standard based on the protection of groundwater meeting the definition of Groundwater Classification1, from RECAP Table 1 when available.
Soil_SSni	Soil screening standard based on the protection of human health for non-industrial land use; from RECAP Ta when available
(1)	Soil level protective of groundwater for inorganic constituents based on GW1 because TCLP value not listed.
*	Chloromethane's Soil_SSGW In RECAP Table 1 is based on Quantitation limits, not the RECAP calculations.
+	Neopentyl glycol data was not available, therefore ethylene glycol was used as a surrogate.
Note:	If the limiting Soil Screening Standard was below the analytical quantitation limits, the analytical quantitation was used as the limiting soil RECAP standard (LDEQ 2000).
[illegible]	Limiting Screening Standards are shaded.

Table 5. Equations for RECAP Screening Standards for Soil and Sample Calculations for Soil, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

$Soil_{SSnc}$ for Noncarcinogenic Effects of Organic Constituents

$$Soil_{SSnc}(mg/kg) = \frac{THQ \times BW_c \times AT_{nc} \times 365 days/yr}{EF_{nc} \times ED_c \left[\left(\left(\frac{1}{RfD_o} \right) \times 10^{-6} \frac{kg}{mg} \times IRS_c \right) + \left(\left(\frac{1}{RfD_i} \right) \times IRA_c \times \left(\frac{1}{VF_{nc}} \right) \right) + \left(\left(\frac{1}{RfD_o} \right) \times SA_c \times AF_c \times ABS \times 10^{-6} \frac{kg}{mg} \right) \right]}$$

$Soil_{SSnc}$ for Carcinogenic Effects of Organic Constituents

$$Soil_{SSnc}(mg/kg) = \frac{TR \times AT_c \times 365 days/yr}{EF_{nc} \times \left[\left(CSF_o \times 10^{-6} \frac{kg}{mg} \times IRS_{adj} \right) + \left(CSF_i \times IRA_{adj} \times \left(\frac{1}{VF_{nc}} \right) \right) + \left(CSF_o \times 10^{-6} \frac{kg}{mg} \times ABS \times IRD_{adj} \right) \right]}$$

$Soil_{SSnc}$ for Noncarcinogenic Effects of Inorganic Constituents

$$Soil_{SSnc}(mg/kg) = \frac{THQ \times BW_c \times AT_{nc} \times 365 days/yr}{EF_{nc} \times ED_c \times \left[\left(\left(\frac{1}{RfD_o} \right) \times 10^{-6} \frac{kg}{mg} \times IRS_c \right) + \left(\left(\frac{1}{RfD_o} \right) \times SA_c \times AF_c \times ABS \times 10^{-6} \frac{kg}{mg} \right) \right]}$$

The following formulas are for both carcinogenic and noncarcinogenic constituents:

$$VF_{nc}(m^3/kg) = \frac{(Q/C) \times (3.14 \times D_A \times T)^{1/2} \times 10^{-4} (m^2/cm^2)}{(2 \times \rho_b \times D_A)}$$

$$D_A(cm^2/s) = \frac{\left[\left(\theta_a^{10/3} D_i H' + \theta_w^{10/3} D_w \right) / n^2 \right]}{\rho_b K_d + \theta_w + \theta_a H'}$$

$$C_{soil}(mg/kg) = \frac{GW_1 \times (\rho_b \times K_d + \theta_w + \theta_a \times H')}{\rho_b}$$

Table 5. Equations for RECAP Screening Standards for Soil and Sample Calculations for Soil, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

GW_{SS} for Noncarcinogenic Effects of Non-volatile Constituents

$$GW_{SS}(mg/L) = \frac{THQ \times BW_a \times AT_{nm} \times 365 days/yr}{EF_{nr} \times ED_{nr} \times \left(\frac{1}{RfD_o} \times IRWa\right)}$$

GW_{SS} for Noncarcinogenic Effects of Volatile Constituents

$$GW_{SS}(mg/L) = \frac{THQ \times BW_a \times AT_{nm} \times 365 days/yr}{EF_{nr} \times ED_{nr} \times \left(\left(\frac{1}{RfD_i} \times K_w \times IRA_a\right) + \left(\left(\frac{1}{RfD_o}\right) \times IRW_a\right)\right)}$$

$$GW_1 = GW_{SS} \times 10$$

GW_{SS} for Carcinogenic Effects of Non-volatile Constituents

$$GW_{SS}(mg/L) = \frac{TR \times AT_c \times 365 days/yr}{EF_{nr} \times \left(CSF_o \times IRW_{adj}\right)}$$

GW_{SS} for Carcinogenic Effects of Volatile Constituents

$$GW_{SS}(mg/L) = \frac{TR \times AT_c \times 365 days/yr}{EF_{nr} \times \left[\left(CSF_i \times K_w \times IRA_{adj}\right) + \left(CSF_o \times IRW_{adj}\right)\right]}$$

$$GW_1 = GW_{SS}$$

$$Soil_{SSGW}(mg/kg) = C_{soil} \times 20$$

Table 5. Equations for RECAP Screening Standards for Soil and Sample Calculations for Soil, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

$$Soil_{sat}(mg/kg) = \frac{S}{\rho_b}\left((K_d \times \rho_b) + \theta_w + \left(H' \times \theta_a\right)\right)$$

Estimation of air and water diffusivities (D_i and D_W)

chemical a = chemical in question
chemical b = phenol (with published diffusivity value)

$$D_i = \frac{D_{ib}}{D_{ia}} = \sqrt{\frac{MW_a}{MW_b}}$$

$$D_W = \frac{D_{Wb}}{D_{Wa}} = \sqrt{\frac{MW_a}{MW_b}}$$

ABS	Dermal absorption factor (unitless)	chemical-specific
AF_c	Child soil-to-skin adherence factor (mg/cm^2)	0.3 mg/cm^2
AT_c	Averaging time – carcinogens (yrs)	70 yr
AT_{nc}	Averaging time – noncarcinogens (yrs)	6 yr
AT_{nni}	Averaging time – noncarcinogens, non-industrial (yr)	30 yr
BW_a	Adult body weight (kg)	70 kg
BW_c	Average child body weight ages 1-6 (kg)	15 kg
C_{soil}	Soil concentration (mg/kg dry weight)	calculated
CSF_i	Inhalation cancer slope factor (mg/kg-day)$^{-1}$	chemical-specific
CSF_o	Oral cancer slope factor (mg/kg-day)$^{-1}$	chemical-specific
D_A	Apparent diffusivity (cm^2/s)	calculated

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Table 5. Equations for RECAP Screening Standards for Soil and Sample Calculations for Soil, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

D_i	Diffusivity in air (cm^2/s)	chemical-specific
D_w	Diffusivity in water (cm^2/s)	chemical-specific
ED_c	Child exposure duration ages 1-6 (yr)	6 yr
ED_m	non-industrial exposure duration (yr)	30 yr
EF_{ni}	non-industrial exposure frequency (days/yr)	350 days/yr
f_{oc}	Fractional organic carbon in soil (g/g); f_{oc} = percent organic matter/174 (ASTM 2974)	0.006 (0.6%)
GW_{SS}	The RECAP groundwater screening standard based on the protection of groundwater meeting the definition of Groundwater Classification 1.	calculated
GW_1	RECAP standard for groundwater meeting the definition of Groundwater Classification 1.	calculated
H	Henry's Law Constant (atm-m^3/mol)	chemical-specific
H'	Dimensionless Henry's Law Constant;H'=H/RT=Hx41	chemical-specific
IRA_a	Adult inhalation rate (m^3/day)	20 m^3/day
IRA_{adj}	Age-adjusted inhalation rate (m^3-yr/kg-day)	11 m^3-yr/kg-day
IRA_c	Child inhalation rate ages 1-6 (m^3/day)	10 m^3/day
IRD_{adj}	Age-adjusted dermal contact rate (mg-yr/kg-day)	504 mg-yr/kg-day
IRS_{adj}	Age-adjusted soil ingestion rate (mg-yr/kg-day)	114 mg-yr/kg-day
IRS_c	Child soil ingestion rate ages 1-6 (mg/day)	200 mg/day
IRW_a	Adult water ingestion rate (L/day)	2 L/day

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Table 5. Equations for RECAP Screening Standards for Soil and Sample Calculations for Soil, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

IRW_{adj}	Age-adjusted water ingestion rate (L-yr/kg-day)	1.1 L-yr/kg-day
K_d	Soil-water partition coefficient (cm^3/g) = K_{oc} x f_{oc}	chemical-specific
K_{oc}	Soil organic carbon partition coefficient (cm^3/g)	chemical-specific
K_w	Water-to-indoor air volatilization factor (L/m^3)	0.5 L/m^3
MW	Molecular weight (g/mole)	chemical-specific
n	Total soil porosity (L_{pore}/L_{soil}); ($1 - \rho_b/\rho_s$)	0.36
ρ_b	Dry soil bulk density (g/cm^3)	1.7
ρ_s	Soil particle density (g/cm^3)	2.65
Q/C	Inverse of the mean concentration at the center of a 0.5-acre-square source (g/m^2-s per kg/m^3)	79.25
RfD_i	Inhalation chronic reference dose (mg/kg-day)	chemical-specific
RfD_o	Oral chronic reference dose (mg/kg-day)	chemical-specific
S	Solubility in water (mg/L-water)	chemical-specific
SA_c	Child surface area (cm^2/day)	2900 cm^2/day
$Soil_{sat}$	Soil saturation concentration (mg/kg)	calculated
$Soil_{SSm}$	Non-industrial risk-based chemical concentration in soil (mg/kg)	calculated
$Soil_{SSGW}$	Screening standard based on the protection of groundwater meeting the definition of Groundwater Clasification 1.	calculated
T	Exposure interval (s) - Noncarcinogen Carcinogen	1.9×10^8 9.5×10^8

Table 5. Equations for RECAP Screening Standards for Soil and Sample Calculations for Soil, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

THQ	Target hazard quotient (unitless)	0.1
TR	Target excess individual lifetime cancer risk (unitless)	10^{-6}
θ_a	Air-filled soil porosity (L_{air}/L_{soil}); ($n-\theta_w$)	0.15
θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.21
VF_m	Non-industrial soil-to-air volatilization factor (m^3/kg)	chemical-specific

SAMPLE CALCULATION : Dicyclopentadiene

Chemical a = dicyclopentadiene
Chemical b = phenol

$$D_i = \frac{0.082 cm^2/s}{D_{ia}} = \sqrt{\frac{132.21 g/mole}{94.11 g/mole}} = 0.0692 cm^2/s$$

$$D_{wi} = \frac{0.000091 cm^2/s}{D_{wa}} = \sqrt{\frac{132.21 g/mole}{94.11 g/mole}} = 7.7x10^{-6} cm^2/s$$

$$D_A = \frac{\left[\left(0.15^{10/3} \times 0.07 cm^2/s \times 0.0107 atm-m^3/mol \times 41\right) + \left(0.21^{10/3} \times 7.7x10^{-6} cm^2/s\right)/0.36^2\right]}{\left(1.7 g/cm^3 \times 5.364 cm^3/g\right) + 0.21 + \left(0.15 \times 0.0107 atm-m^3/mol \times 41\right)}$$

$$= \frac{4.1x10^{-4}}{9.4} = 4.4x10^{-5} cm^2/s$$

$$VF_m = \frac{79.25 \times \left(3.14 \times 4.4x10^{-5} cm^2/s \times 1.9x10^8 s\right)^{1/2} \times 10^{-4}}{2 \times 1.7 \times 4.4x10^{-5} cm^2/s}$$

Table 5. Equations for RECAP Screening Standards for Soil and Sample Calculations for Soil, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

$$= \frac{1.3}{0.00015} = 8620 m^3 / kg$$

$$Soil_{SSni} = \frac{0.1 \times 15 \times 6 \times 365}{350 \times 6 \times \left[\left(\left(\frac{1}{3x10^{-2}}\right) \times 10^{-6} \times 200\right) + \left(\left(\frac{1}{5.7x10^{-5}}\right) \times 10 \times \left(\frac{1}{8620}\right)\right) + \left(\left(\frac{1}{3x10^{-2}}\right) \times 2900 \times 0.3 \times 0.1 \times 10^{-6}\right)\right]}$$

$$= \frac{3285}{2100(20.4)} = 0.08 \ mg / kg$$

$$GW_{SS} = \frac{0.1 \times 70 kg \times 30 y \times 365 days / yr}{350 d / y \times 30 y \times \left[\left(\frac{1}{6x10^{-5}} \times 0.5 L m^3 \times 20 m^3 / day\right) + \left(\frac{1}{3x10^{-2} mg / kg - d} \times 2 L / d\right)\right]}$$

$$= \frac{76650}{1.75x10^9} = 4.4x10^{-5} mg / L$$

The analytical quantitation limit for Dicyclopentadiene in groundwater is 0.01 mg/L, therefore this value was used for GW_1 in the Csoil equation below.

$$Csoil = \frac{0.01 mg / L\left(1.7 g / cm^3 \times 5.364 cm^3 / g + 0.21 + 0.15 \times 0.011 atm - m^3 / mol \times 41\right)}{1.7 g / cm^3} = 0.055 mg / kg$$

$$Soil_{SSGW} = 0.055 mg / kg \times 20 = 1.11 mg / kg$$

Dicyclopentadiene is not soluble in water, therefore the $Soil_{sat}$ is considered not applicable.

Table 5. Equations for RECAP Screening Standards for Soil and Sample Calculations for Soil, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

SAMPLE CALCULATION : Acrylic Acid

Chemical a = Acrylic Acid
Chemical b = phenol

$$D_i = \frac{0.082 cm^2/s}{D_{ia}} = \sqrt{\frac{72.06 g/mole}{94.11 g/mole}} = 0.094 cm^2/s$$

$$D_{wi} = \frac{0.000009 1 cm^2/s}{D_{wa}} = \sqrt{\frac{72.06 g/mole}{94.11 g/mole}} = 1.04x10^{-5} cm^2/s$$

$$D_A = \frac{\left[\left(0.15^{10/3} \times 0.094 cm^2/s \times 3.2x10^{-7} atm-m^3/mol \times 41\right) + \left(0.21^{10/3} \times 1.04x10^{-5} cm^2/s\right)/0.36^2\right]}{\left(1.7 g/cm^3 \times 5.364 cm^3/g\right) + 0.21 + \left(0.15 \times 3.2x10^{-7} atm-m^3/mol \times 41\right)}$$

$$= \frac{4.6x10^{-7}}{0.65} = 7.1x10^{-7} cm^2/s$$

$$VF_{ni} = \frac{79.25 \times \left(3.14 \times 7.1x10^{-7} cm^2/s \times 1.9x10^{8} s\right)^{1/2} \times 10^{-4}}{2 \times 1.7 \times 7.1x10^{-7} cm^2/s}$$

$$= \frac{0.16}{2.4x10^{-6}} = 67668 m^3/kg$$

$$Soil_{SSni} = \frac{0.1 \times 15 \times 6 \times 365}{350 \times 6 \times \left[\left(\left(\frac{1}{0.5}\right) \times 10^{-6} \times 200\right) + \left(\left(\frac{1}{0.00029}\right) \times 10 \times \left(\frac{1}{67668}\right)\right) + \left(\left(\frac{1}{0.5}\right) \times 2900 \times 0.3 \times 0.1 \times 10^{-6}\right)\right]}$$

$$= \frac{3285}{2100(0.51)} = 3.06 mg/kg$$

Table 5. Equations for RECAP Screening Standards for Soil and Sample Calculations for Soil, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

$$GW_{SS} = \frac{0.1 \times 70kg \times 30y \times 365d/y}{350d/y \times 30y \times \left(\frac{1}{0.5mg/kg-d} \times 2L/d\right)}$$

$$= \frac{76650}{42000} = 1.8mg/L$$

$$C_{soil} = \frac{10 \times 1.8mg/L\left[\left(1.7g/cm^3 \times 0.258cm^3/g\right) + 0.21 + \left(0.15 \times 3.2x10^{-7}\ \frac{atm-m^3}{mol} \times 41\right)\right]}{1.7g/cm^3} = 6.963mg/kg$$

$$Soil_{SSGW} = 6.963mg/kg \times 20 = 139mg/kg$$

$$Soil_{sat} = \frac{1x10^6\ mg/L}{1.7g/cm^3}\left[\left(0.26cm^3/g \times 1.7g/cm^3\right) + 0.21 + \left(3.2x10^{-7}\ \frac{atm-m^3}{mol} \times 41 \times 0.15\right)\right]$$

$$= 5.9x10^5\left(0.44 + 0.21 + 1.95x10^{-6}\right) = 3.8x10^5\ mg/kg$$

SAMPLE CALCULATION : 2,4-Toluenediamine

Chemical a = 2,4-toluenediamine
Chemical b = phenol

$$D_i = \frac{0.082cm^2/s}{D_{ia}} = \sqrt{\frac{122.17g/mole}{94.11g/mole}} = 0.072cm^2/s$$

$$D_{wi} = \frac{0.0000091cm^2/s}{D_{wia}} = \sqrt{\frac{122.17g/mole}{94.11g/mole}} = 7.99x10^{-6}cm^2/s$$

Table 5. Equations for RECAP Screening Standards for Soil and Sample Calculations for Soil, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

$$D_A = \frac{\left[\left(0.15^{10/3} \times 0.072 cm^2/s \times 1.2x10^{-9} atm-m^3/mol \times 41\right) + \left(0.21^{10/3} \times 7.99x10^{-6} cm^2/s\right)/0.36^2\right]}{\left(1.7 g/cm^3 \times 0.013 cm^3/g\right) + 0.21 + \left(0.15 \times 1.2x10^{-9} atm-m^3/mol \times 41\right)}$$

$$= 1.47x10^{-6} cm^2/s$$

$$VF_{ni} = \frac{79.25 \times \left(3.14 \times 1.47x10^{-6} cm^2/s \times 9.5x10^8 s\right)^{1/2} \times 10^{-4}}{2 \times 1.7 \times 1.47x10^{-6} cm^2/s}$$

$$= \frac{0.52}{5x10^{-6}} = 1.05x10^5 m^3/kg$$

$$Soil_{SSni} = \frac{10^{-6} \times 70 \times 365}{350 \times \left[\left(3.2x10^{-6} \times 114\right) + \left(3.2 \times 11 \times \left(\frac{1}{1.05x10^5}\right)\right) + \left(3.2x10^{-6} \times 0.1 \times 504\right)\right]}$$

$$= \frac{0.025}{0.3025} = 0.08 mg/kg$$

$$GW_{SS} = \frac{10^{-6} \times 70 yrs \times 365 days/yr}{350 d/y \times (3.2 \times 1.1)}$$

$$= \frac{0.025}{1232} = 2.0x10^{-5} mg/L$$

The analytical quantitation limit for 2,4-Toluenediamine in groundwater is 0.02 mg/L, therefore this value was used for GW_i in the Csoil equation below.

$$C_{soil} = \frac{0.02 mg/L\left(1.7 g/cm^3 \times 0.013 cm^3/g + 0.21 + 0.15 \times 1.2x10^{-9} atm-m^3/mol \times 41\right)}{1.7 g/cm^3} = 0.00274 mg/kg$$

Table 5. Equations for RECAP Screening Standards for Soil and Sample Calculations for Soil, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

$$Soil_{SSGW} = 0.00274 mg/kg \times 20 = 0.055 mg/kg$$

$$Soil_{sat} = \frac{7.74 mg/L}{1.7 g/cm^3}\left[\left(0.013 cm^3/g \times 1.7 g/cm^3\right) + 0.21 + \left(1.2x10^{-9} atm - m^3/mol \times 41 \times 0.15\right)\right]$$

$$= 4.55\left(0.0221 + 0.21 + 7.4x10^{-9}\right) = 1.06 mg/kg$$

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Table 6. Calculation of RECAP Screening Standards for Groundwater, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

Constituent	Carcinogenic GW_SS (mg/L)	Noncarcinogenic GW_SS (mg/L)	Minimum Value (mg/L)	Quantitation Limit (mg/L)
Acrylic Acid	NC	1.83	1.83	0 05
Aluminum	NC	3.65	3.65	0.5
Caprolactam	NC	1.83	1.83	0.01
Chloromethane(Methyl Chloride)	0.002	0.005	0.002	0.002
Cyanide (total)	NC	0.073	0.073	0.01
1,2-Dichloropropane	NA	NA	0.005*	0.001
Dicyclopentadiene	NC	0.00004	0.00004	0.01
Disodium Iminodiacetate	NC	NA	NA	NA
Ethylene Glycol	NC	7.30	7.30	5.0
n-Hexane	NC	0.035	0.035	0.005
Neopentyl glycol +	NC	1.22	1.22	0.01
Pentane	NC	0.035	0.035	0.005
Phenol	NC	0.365	0.365	0.01
2,4-Toluenediamine	0.00002	NA	0.00002	0.025
Toluene Diisocyanate	0.00029	0.000015	0.000015	0.02

mg/L	Milligrams per liter.
NA	Not available
NC	Not a carcinogen.
RECAP	Risk Evaluation/Corrective Action Program
*	The minimum value for 1,2-Dichloropropane is the MCL value according to RECAP Worksheet 3.
+	Neopentyl glycol data were not available, therefore ethylene glycol was used as a surrogate.
Note:	If the GW_SS was below the analytical quantitation limits, the analytical quantitation limit was used as the limiting groundwater RECAP standard (LDEQ 2000).
	The shaded value was determined to be the limiting screening standard or the analytical quantitation limit.

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Table 7. Equations for RECAP Screening Standards for Groundwater and Sample Calculations for Groundwater, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

GW_{SS} for Noncarcinogenic Effects of Non-volatile Constituents

$$GW_{SS}(mg/L) = \frac{THQ \times BW_a \times AT_{nn} \times 365 days/yr}{EF_{ni} \times ED_{ni} \times \left(\frac{1}{RfD_o} \times IRWa\right)}$$

GW_{SS} for Noncarcinogenic Effects of Volatile Constituents

$$GW_{SS}(mg/L) = \frac{THQ \times BW_a \times AT_{nn} \times 365 days/yr}{EF_{ni} \times ED_{ni} \times \left(\left(\frac{1}{RfD_i} \times K_w \times IRA_a\right) + \left(\left(\frac{1}{RfD_o}\right) \times IRW_a\right)\right)}$$

$$GW_1 = GW_{SS} \times 10$$

GW_{SS} for Carcinogenic Effects of Volatile Constituents

$$GW_{SS}(mg/L) = \frac{TR \times AT_c \times 365 days/yr}{EF_{ni} \times \left[\left(CSF_i \times K_w \times IRA_{adj}\right) + \left(CSF_o \times IRW_{adj}\right)\right]}$$

GW_{SS} for Carcinogenic Effects of Non-volatile Constituents

$$GW_{SS}(mg/L) = \frac{TR \times AT_c \times 365 days/yr}{EF_{ni} \times \left(CSF_o \times IRW_{adj}\right)}$$

$$GW_1 = GW_{SS}$$

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Table 7. Equations for RECAP Screening Standards for Groundwater and Sample Calculations for Groundwater, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

AT_c	Averaging time – carcinogens(yrs)	70 yr
AT_{nni}	Averaging time – noncarcinogens, non-industrial (yr)	30 yr
BW_a	Adult body weight (kg)	70 kg
CSF_i	Inhalation cancer slope factor $(mg/kg\text{-}day)^{-1}$	chemical-specific
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	chemical-specific
ED_{ni}	non-industrial exposure duration (yr)	30 yr
EF_{ni}	non-industrial exposure frequency (days/yr)	350 days/yr
GW_{SS}	The RECAP groundwater screening standard based on the protection of groundwater meeting the definition of Groundwater Classification 1.	calculated
GW_1	RECAP standard for groundwater meeting the definition of Groundwater Classification 1.	calculated
IRA_a	Adult inhalation rate (m^3/day)	20 m^3/day
IRA_{adj}	Age-adjusted inhalation rate (m^3-yr/kg-day)	11 m^3-yr/kg-day
IRA_c	Child inhalation rate ages 1-6 (m^3/day)	10 m^3/day
IRW_a	Adult water ingestion rate (L/day)	2 L/day
IRW_{adj}	Age-adjusted water ingestion rate (L-yr/kg-day)	1.1 L-yr/kg-day
K_w	Water-to-indoor air volatilization factor (L/m^3)	0.5 L/m^3
RfD_i	Inhalation chronic reference dose (mg/kg-day)	chemical-specific
RfD_o	Oral chronic reference dose (mg/kg-day)	chemical-specific

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Table 7. Equations for RECAP Screening Standards for Groundwater and Sample Calculations for Groundwater, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

THQ	Target hazard quotient (unitless)	0.1
TR	Target excess individual lifetime cancer risk (unitless)	10^{-6}

SAMPLE CALCULATION : Dicyclopentadiene

$$GW_{SS} = \frac{0.1 \times 70kg \times 30y \times 365days/yr}{350d/y \times 30y \times \left[\left(\frac{1}{6x10^{-5}} \times 0.54m^3 \times 20m^3/day\right) + \left(\frac{1}{3x10^{-2}\,mg/kg-d} \times 2L/d\right)\right]}$$

$$= \frac{76650}{1.75x10^{9}} = 4.4x10^{-5}\,mg/L$$

SAMPLE CALCULATION : Acrylic Acid

$$GW_{SS} = \frac{0.1 \times 70kg \times 30y \times 365d/y}{350d/y \times 30y \times \left(\frac{1}{0.5mg/kg-d} \times 2L/d\right)}$$

$$= \frac{76650}{42000} = 1.8mg/L$$

SAMPLE CALCULATION : 2,4-Toluenediamine

$$GW_{SS} = \frac{10^{-6} \times 70kg \times 365days/yr}{350d/y \times (3.2 \times 1.1)}$$

$$= \frac{0.025}{1232} = 2.0x10^{-5}\,mg/L$$

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Table 8 Calculation of RECAP Standards for Surface Water, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana

Constituent	Carcinogenic SWNDW (mg/L)	Noncarcinogenic SWNDW (mg/L)	Minimum Value (mg/L)	Quantitation Limit (mg/L)
Acrylic Acid	NC	321.10	[redacted]	0 05
Aluminum	NC	636 47	[redacted]	0 5
Caprolactam	NC	228 76	[redacted]	0 01
Chloromethane(Methyl Chloride)	0 037	41 01	[redacted]	0 002
Cyanide (total)	NC	12 84	[redacted]	0 01
1,2-Dichloropropane	0 002	0 17	[redacted]	0 001
Dicyclopentadiene	NC	1 08	[redacted]	0 01
Disodium Iminodiacetate	NA	NA	NA	NA
Ethylene Glycol	NC	484	[redacted]	5 0
n-Hexane	NC	43 21	[redacted]	0 005
Neopentyl glycol[+]	NC	484 0	[redacted]	20 0
n-Pentane	NC	43 93	[redacted]	0 005
Phenol	NC	166 93	[redacted]	0 01
2,4-Toluenediamine	0 0002	NA	0 0002	[redacted]
Toluene Diisocyanate	0 00022	1 94	0 00022	[redacted]

BCF	Bioconcentration factor (L/kg) -- chemical specific
BWa	Adult Body Weight (70 kg)
CSF_o	Oral cancer slope factor $(mg/kg/day)^{-1}$ -- chemical specific
IRF	Fish/Shellfish ingestion rate (0 02 kg/day)
IRW_{NDW}	Incidental water ingestion rate (0 089 L/day)
log Kow	Log of the octanol/water partition coefficient
MCL	Maximum contaminant level
mg/L	Milligrams per liter
RECAP	Risk Evaluation/Corrective Action Program
RfD_o	Oral reference dose (mg/kg/day) -- chemical specific
SWNDW	Risk-Based Concentration in surface water (mg/L)
NA	Not available
THQ	Target Hazard quotient (unitless) -- 1
TR	Target Risk Level (unitless) -- 10^{-6}
*	The minimum value for 1,2-Dichloropropane is the MCL value according to RECAP Worksheet 3
+	Neopentyl glycol data were not available, therefore ethylene glycol was used as a surrogate
Note	If the SWNDW was below the analytical quantitation limits, the analytical quantitation limit was used as the limiting groundwater RECAP standard (LDEQ 2000)
[redacted]	The shaded value was determined to be the limiting standard or the analytical quantitation limit

Equation taken from GW3NDW equation and is consistent with Human Health Numerical Criteria Derivations for Toxic Substances, LDEQ 1994

noncarcinogenic

$$SWNDW = (THQ \times RfD \times BW) / (IRW_{NDW} + (BCF \times IRF))$$

carcinogenic

$$SWNDW = (TR^{*}BW)/(CSF^{*}(IRW_{NDW} + (BCF \times IRF)))$$

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Table 9. Equations for RECAP Standards for Surface Water and Sample Calculations for Surface Water, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

SW_{NDW} for Noncarcinogenic Effects

$$SW_{NDW} = \frac{THQ \times RfD_o \times BW_a}{IRW_{NDW} + (BCF \times IRF)}$$

SW_{NDW} for Carcinogenic Effects

$$SW_{NDW} = \frac{TR \times BW_a}{CSF_o \times (IRW_{NDW} + (BCF \times IRF))}$$

When chemical-specific data were not available, the following formulas were used.

$$LogBCF = 0.76 \log K_{OW} - 0.23$$

$$LogK_{OC} = 0.0784 + (0.7919 \times \log K_{OW})$$

BCF	Bioconcentration factor	chemical-specific
BW_a	Adult body weight (kg)	70 kg
CSF_o	Oral cancer slope factor	chemical-specific
IRF	Fish/Shellfish ingestion rate (kg/day)	0.02 kg/day
IRW_{NDW}	Incidental water ingestion rate (L/day)	0.089 L/day
K_{OC}	Organic carbon/water partition coefficient	chemical-specific
K_{OW}	Octanol/water partition coefficient	chemical-specific
RfD_o	Oral chronic reference dose (mg/kg-day)	chemical-specific
SW_{NDW}	Risk-based concentration in surface water (mg/L)	calculated
THQ	Target hazard quotient (unitless)	1
TR	Target excess individual lifetime carner risk (unitless)	10^{-6}

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Table 10 Calculation of Risk-Based Concentrations for Edible Fish (Based on EPA Region III RBC Table and Equations), Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

Constituent	Carcinogen (mg/kg)	Non-Carcinogen (mg/kg)	Calculated RBC (mg/kg)	Region III RBC (mg/kg)	Detection Limits (mg/kg)
Acrylic Acid	NC	1825	[illegible]	NA	100
Aluminum	NC	3650	[illegible]	1400	8
Caprolactam	NC	1825	[illegible]	680	1
Chloromethane	0.6551	314	[illegible]	0.24	0.05
Cyanide	NC	73	[illegible]	27	0.5
1,2-Dichloropropane	0.1252	4	[illegible]	0.05	0.046
Dicyclopentadiene	NC	110	[illegible]	41	1
Disodium Iminodiacetate	NA	NA	NA	NA	1.2
Ethylene Glycol	NC	7300	[illegible]	2700	NA
n-Hexane	NC	219	[illegible]	81	NA
Neopentyl glycol+	NC	7300	[illegible]	NA	4
n-Pentane *	NC	219	[illegible]	81	NA
Phenol	NC	2190	[illegible]	810	0.33
2,4-Toluenediamine	0.0027	NA	0.003	0.001	[illegible]
Toluene diisocyanate	0.2184	840	0.22	NA	[illegible]

NA Not available.
NC Not a carcinogen.
mg/kg Milligrams per kilogram.
RBC Risk-Based Concentrations.
* Pentane data was not available, therefore hexane was used as a surrogate.
+ Neopentyl glycol data was not available, therefore ethylene glycol was used as a surrogate.
Note: The formulas used to calculate the RBCs above are from EPA Region III.
The fish ingestion rate was adjusted to meet the values in LDEQ RECAP.
[illegible] The shaded value was determined to be the limiting screening standard or the analytical quantitation limit.

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Table 11. Equations for Risk-Based Concentrations for Edible Fish and Sample Calculations for Risk-Based Concentrations for Edible Fish, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

RBC for Noncarcinogenic Effects

$$RBC = \frac{THQ \times RfD_o \times BW_a \times AT_n}{EF_r \times ED_{tot}\left(\frac{IRF}{1000\ g/kg}\right)}$$

RBC for Carcinogenic Effects

$$RBC = \frac{TR \times BW_a \times AT_c}{EF_r \times ED_{tot} \times \left(\frac{IRF}{1000 g/kg}\right) \times CSF_o}$$

AT_c	Averaging time for carcinogens (days)	25550 days
AT_n	Averaging time for noncarcinogens (days)	10950 days
BW_a	Adult body weight (kg)	70 kg
CSF_o	Oral cancer slope factor $(mg/kg\text{-}day)^{-1}$	chemical-specific
ED_{tot}	Total exposure duration (years)	30 y
EF_r	Exposure frequency (days/year)	350 d/y
IRF	Fisk ingestion rate (g/day)	20 g/day
RBC	Risk-based concentrations (mg/kg)	calculated
RfD_o	Oral reference dose (mg/kg-day)	chemical-specific
THQ	Target hazard quotient (unitless)	1
TR	Target excess individual lifetime cancer risk (unitless)	10^{-6}

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Table 11. Equations for Risk-Based Concentrations for Edible Fish and Sample Calculations for Risk-Based Concentrations for Edible Fish, Union Pacific Derailment Site, Union Pacific Railroad Company, Eunice, Louisiana.

Sample Calculation : Dicyclopentadiene

$$RBC = \frac{1 \times 0.03 \frac{mg}{kg - d} \times 70\,kg \times 10950\,d}{350\,d/yr \times 30\,y \times \left(\frac{20\,g/day}{1000\,g/kg}\right)} = 110\,mg/kg$$

Sample Calculation : Acrylic Acid

$$RBC = \frac{1 \times 0.5 \frac{mg}{kg - d} \times 70\,kg \times 10950\,d}{350\,d/yr \times 30\,y \times \left(\frac{20\,g/day}{1000\,g/kg}\right)} = 1825\,mg/kg$$

Sample Calculation : 2,4-Toluenediamine

$$RBC = \frac{10^{-6} \times 70\,kg \times 25550\,days}{350\,d/yr \times 30\,y \times \left(\frac{20\,g/day}{1000\,g/kg}\right) \times 3.2\left(\frac{mg}{kg - day}\right)^{-1}} = 0.003\,mg/kg$$